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CENTRAL FAX CENTER****MAY 03 2006****FACSIMILE COVER SHEET**Deliver to: Shin, Christopher B., USPTOArt Group: 2182Facsimile No.: (571) 273-8300Date: May 3, 2006From: Chui-Kiu Teresa Wong, Reg. No. 48,042Our Docket No.: 42390P6344Number of pages 44 including this sheet.Application No.: 09/186,056Filing Date: 11/3/1998

Docket Due Date(s): _____ | _____

Enclosed are the following documents:

<input type="checkbox"/> Amendment: _____ (____ pgs)	<input type="checkbox"/> Issue Fee Transmittal
<input type="checkbox"/> Appeal Brief (____ pgs).	<input type="checkbox"/> Notice of Appeal
<input type="checkbox"/> Application: _____ (____ pgs) w/cover & abstract)	<input checked="" type="checkbox"/> Petition for: <u>Correction of Filing Date</u>
<input type="checkbox"/> Assignment & Cover Sheet (____ pgs)	<input type="checkbox"/> Request for Continued Examination (RCE)
<input type="checkbox"/> Certificate of _____	<input type="checkbox"/> Reply Brief (____ pgs)
<input type="checkbox"/> Continued Prosecution Application (CPA)	<input type="checkbox"/> Request & Certification Under 35 USC 122(b)(2)(B)(i)
<input type="checkbox"/> Declaration & POA (____ pgs)	<input type="checkbox"/> Request to Rescind Previous Nonpublication Request
<input type="checkbox"/> Drawings: ____ sheets, ____ figures	<input type="checkbox"/> Response to Notice of Missing Parts & Formalities Letter
<input type="checkbox"/> Extension of Time: _____	<input type="checkbox"/> Response to Written Opinion (____ pgs)
<input type="checkbox"/> Fee Transmittal (in duplicate)	<input type="checkbox"/> Terminal Disclaimer
<input type="checkbox"/> IDS & PTO/SB/08 (____ pgs)	<input type="checkbox"/> Transmittal of Publication Fee Due
<input checked="" type="checkbox"/> Other Originally filed application, copy of postcard returned by the USPTO, previous petition filed and notice of withdrawal of previously sent notice.	<input type="checkbox"/> Transmittal Letter

CERTIFICATE OF MAILING/TRANSMISSION (37 CFR 1.8A)

I hereby certify that this correspondence is being transmitted by facsimile on the date shown below to the United States Patent and Trademark Office.


 Date
 5/3/2006
 Vanessa Sanchez

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042390.P6344
09/186,056

Patent

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

RECEIVED
CENTRAL FAX CENTER

In re Application of:

David I. Poisner, et al.

Application No.: 09/186,056

Filed: November 3, 1998

Attorney Docket No.: 042390.P6344

For: RACE FREE DATA TRANSFER
ALGORITHM USING HARDWARE
BASED POLLING

MAY 03 2006

Examiner: Shin, Christopher B.

Art Unit: 2182

Office of Petitions
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

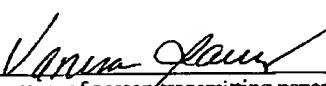
PETITION TO CORRECT FILING DATE
37 C.F.R. § 1.181(a)

In response to the Notice of Allowance mailed February 9, 2006, Applicants respectfully request the correction of the filing date in view of the remarks herein:

CERTIFICATE OF TRANSMISSION VIA FACSIMILE

I hereby certify that this correspondence is being facsimile transmitted to the U.S. Patent and Trademark Office on: May 3, 2006.

Vanessa Sanchez
(Typed or printed name of person transmitting paper)


(Signature of person transmitting paper)

STATEMENTS OF FACTS

Applicant hereby petitions to request correction of the filing date of the current application. The current application was originally filed on November 3, 1998 with a specification, drawings, a list of claims, and the appropriate fee. Since Applicant never received the notice of missing parts, and therefore, was unable to respond, the application was held to be abandoned and a notice of abandonment was mailed on October 28, 2003. Accordingly, Applicant timely filed a petition on December 19, 2003, which the USPTO received on December 22, 2003. The petition was granted and a notice of withdrawal of previously sent notice was mailed on December 1, 2004. However, instead of according the original filing date (November 3, 1998) to the current application, the date the USPTO received the previously petition (December 22, 2003) was erroneously designated as the filing date of the current application.

ACTION REQUESTED

Applicant therefore requests that the filing date of the current application be corrected to be November 3, 1998.

Applicant has submitted herewith a copy of the originally filed application, the postcard returned by the USPTO, the previous petition filed, and the notice of withdrawal of previously sent notice.

If there is a deficiency in fees, please charge our Deposit Account No. 02-2666.

Respectfully submitted,
BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP

Date: 5/3, 2006


Chui-kiu Teresa Wong
Attorney for Applicant
Reg. No. 48,042

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Los Angeles, California 90025-1026
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REQUEST FOR CORRECTED DATE OF FILING		Docket Number 42390P6344								
<p>In re Application of David Poisner, et al.</p> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%;">Application Number</td> <td style="width: 50%;">Filed</td> </tr> <tr> <td>09/186,056</td> <td>11/3/1998</td> </tr> <tr> <td colspan="2" style="text-align: center; padding: 2px;">For RACE FREE DATA TRANSFER ALGORITHM USING HARDWARE BASED POLLING</td> </tr> <tr> <td style="text-align: center; padding: 2px;">Group Art Unit 2182</td> <td style="text-align: center; padding: 2px;">Examiner Shin, Christopher B.</td> </tr> </table>			Application Number	Filed	09/186,056	11/3/1998	For RACE FREE DATA TRANSFER ALGORITHM USING HARDWARE BASED POLLING		Group Art Unit 2182	Examiner Shin, Christopher B.
Application Number	Filed									
09/186,056	11/3/1998									
For RACE FREE DATA TRANSFER ALGORITHM USING HARDWARE BASED POLLING										
Group Art Unit 2182	Examiner Shin, Christopher B.									
<p>1. Attached is a copy of the Originally filed application, returned postcard, previously filed petition, notice of withdrawal of previously sent notice received from the PTO in the above application for which issuance of a corrected Originally filed application, returned postcard, previously filed petition, notice of withdrawal of previously sent notice is respectfully requested.</p> <p>2. There is an error with respect to the following data, which is:</p> <p><input checked="" type="checkbox"/> Incorrectly entered and/or <input type="checkbox"/> omitted.</p>										
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="text-align: center; padding: 2px;">Error in</th> <th style="text-align: center; padding: 2px;">Correct Data</th> </tr> </thead> <tbody> <tr> <td style="padding: 2px;">Filing Date</td> <td style="padding: 2px; text-align: center;">November 3, 1998</td> </tr> <tr> <td style="padding: 2px;">December 22, 2003</td> <td></td> </tr> </tbody> </table>	Error in	Correct Data	Filing Date	November 3, 1998	December 22, 2003		<p>Respectfully submitted, BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP</p> <p> _____ Chui-Kiu Teresa Wong, Reg. No. 48,042</p> <p>CERTIFICATE OF MAILING/TRANSMISSION I hereby certify that this correspondence is being transmitted via facsimile on the date shown below to the United States Patent and Trademark Office.</p> <p> _____ Vanessa Sanchez</p> <p style="text-align: right;">05/03/06 Date</p>			
Error in	Correct Data									
Filing Date	November 3, 1998									
December 22, 2003										
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156



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APPLICATION NUMBER	FILING OR 371(c) DATE	FIRST NAMED APPLICANT	ATTY. DOCKET NO./TITLE
09/186,056		DAVID I. POISNER	042390.P6344

CONFIRMATION NO. 1348

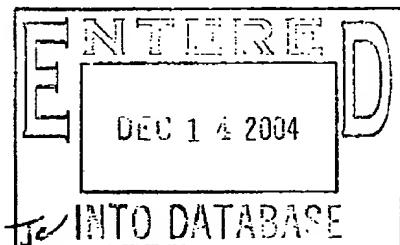
BLAKLEY SOKOLOFF TAYLOR & ZAFMAN
 12400 WILSHIRE BOULEVARD
 7TH FLOOR
 LOS ANGELES, CA 90025

WITHDRAWAL NOTICE
 OC000000012864390
 OC000000012864390

Date Mailed: 12/01/2004

WITHDRAWAL OF PREVIOUSLY SENT NOTICE

The Notice of Abandonment mailed on 10/28/2003 was sent in error and is hereby withdrawn. A Filing Receipt is enclosed. The Office regrets any inconvenience the error may have caused.



R E C E I V E D
 DEC 06 2004
 BLAKLEY, SOKOLOFF, TAYLOR & ZAFMAN LLP
 LOS ANGELES

A copy of this notice MUST be returned with the reply.

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 PART 1 - ATTORNEY/APPLICANT COPY

Docket No.: 42390.P6344

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the application of:)
Poisner et al.)
Serial No.: 09/186,056) Examiner: TBD
Filed: 11/3/98) Art Unit: TBD
For: RACE FREE DATA TRANSFER)
ALGORITHM USING HARDWARE)
BASED POLLING)

PETITION TO WITHDRAW HOLDING OF ABANDONMENT BASED ON FAILURE
TO RECEIVE OFFICE COMMUNICATION
37 CFR § 1.181(a)

Hon. Commissioner of
Patent & Trademarks
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

In response to the Notice of Abandonment mailed 10/28/03, applicants respectfully requests withdrawal of holding of abandonment for the above referenced application in view of applicant's remarks herein.

42390.P6344
Serial #: 09/186,056

-1-

STATEMENT OF FACTS

Applicant hereby petitions to request withdrawal of the holding of abandonment mailed 10/28/2003. The abandonment was held due to an alleged failure to respond to a Notice of Missing Parts. As detailed below, applicants never received this notice of missing parts and therefore were unable to respond. Applicant submits herewith the appropriate response to the Notice of Missing Parts as well as the proof required to justify withdrawal of the holding of abandonment specified in the MPEP.

According to MPEP § 711.03(c), the showing required to establish nonreceipt of an Office communication must include a statement from the practitioner stating that the Office communication was not received by the practitioner and attesting to the fact that a search of the file jacket and docket records indicates that the Office communication was not received. A copy of the docket record where the nonreceived Office communication would have been entered had it been received and docketed must be attached to and referenced in practitioner's statement.

Accordingly, it is hereby submitted that:

1. A search of the above-referenced patent file, Intel docket number P6344, Ser. No. 09/186,056 was performed, and indicated that the Notice of Missing Parts, allegedly mailed by the Patent Office on 11/19/98 was never received because it was not present in the file.
2. Notably, a request for status was sent to the Patent Office requesting information about the status of the case on 11/6/2000 due to the long latency without any communications being received from the Patent Office.
3. A search of the docket records pertinent to this file was also performed and also

42390.P6344
Serial #: 09/186,056

-2-

indicated that the Notice of Missing Parts was never received by applicants. A copy of the docket record where the non-received Notice of Missing Parts would have been entered had it been received and docketed is attached.

ACTION REQUESTED

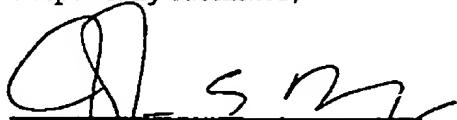
Applicants therefore request that the holding of abandonment based on applicants' alleged failure to respond to the Notice of Missing Parts be withdrawn. Applicant submits that this request was timely submitted within 2 months of the notice of abandonment mailed 10/28/03.

Applicants have submitted herewith the signatures required for this case, although since no notice of missing parts was received, no copy of such notice is enclosed.

If there is a deficiency in fees, please charge our Deposit Acct. No. 02-2666.

Date: 12/19/03

Respectfully submitted,


Jeffrey S. Draeger, Reg. No. 44,000

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Los Angeles, CA 90025-1026
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42390.P6344
Serial #: 09/186,056

-3-

FIRST CLASS CERTIFICATE OF MAILING
(37 C.F.R. § 1.8(a))

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on 12/19/03.

Date of Deposit

Patricia M. Richard

Name of Person Mailing Correspondence

P.M. Richard

Signature

12/19/03

Date

42390.P6344
Serial #: 09/186,056

-4-

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NOV 13 1998

STATUS DB-LA

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN
LOS ANGELES

W X

P D

Serial/Patent No.: <u>**</u>	Filing/Issue Date: <u>Herewith</u>
Client: <u>INTEL CORPORATION</u>	
Title: <u>a race free data transfer algorithm using hardware based polling</u>	
BSTZ File No.: <u>042390.P6344</u>	Att'y/Secty Initials: <u>EHT/JSD/jkm</u>
Date Mailed: <u>11/13/98</u>	Docket Due Date: <u>**</u>
The following has been received in the U.S. Patent & Trademark Office on the date stamped hereon:	
<input type="checkbox"/> Amendment/Response (<u> </u> pgs.) <input type="checkbox"/> Express Mail No. <u>EM335898998US</u> <input checked="" type="checkbox"/> Check No. <u>250-78</u> <input type="checkbox"/> Appeal Brief (<u> </u> pgs.) (in triplicate) <input type="checkbox"/> Month(s) Extension of Time <u> </u> Amt: <u>1020.00</u> <input checked="" type="checkbox"/> Assignment, Transfer or Recordation, with cover and abstract <input type="checkbox"/> Information Disclosure Statement & PTO-149 (<u> </u> pgs.) <input type="checkbox"/> Check No. <u> </u> <input type="checkbox"/> Application - Rule 1.53(b) Continuation (<u> </u> pgs.) <input type="checkbox"/> Issue Fee Transmittal <u> </u> Amt: <u> </u> <input type="checkbox"/> Application - Rule 1.53(b) Divisional (<u> </u> pgs.) <input type="checkbox"/> Notice of Appeal <u> </u> <input type="checkbox"/> Application - Rule 1.53(b) CIP (<u> </u> pgs.) <input type="checkbox"/> Petition for Extension of Time <u> </u> <input type="checkbox"/> Application - Rule 1.53(d) CPA Transmittal (<u> </u> pgs.) <input type="checkbox"/> Petition for <u> </u> <input type="checkbox"/> Application - Design (<u> </u> pgs.) <input type="checkbox"/> Postcard <u> </u> <input type="checkbox"/> Application - PCT (<u> </u> pgs.) <input type="checkbox"/> Power of Attorney (<u> </u> pgs.) <input type="checkbox"/> Application - Provisional (<u> </u> pgs.) <input type="checkbox"/> Preliminary Amendment (<u> </u> pgs.) <input type="checkbox"/> Assignment and Cover Sheet <input type="checkbox"/> Reply Brief (<u> </u> pgs.) <input type="checkbox"/> Certificate of Mailing <input type="checkbox"/> Response to Notice of Missing Parts <input checked="" type="checkbox"/> Declaration & POA (<u>4</u> pgs.) <u>unsigned</u> <input type="checkbox"/> Small Entity Declaration for Indep. Inventor/Small Business <input type="checkbox"/> Declares Dirs & Oig & Copy of Inventor Signed Letter (<u> </u> pgs.) <input checked="" type="checkbox"/> Transmittal Letter, in duplicate <input checked="" type="checkbox"/> Drawings (<u>16</u> * of sheet includes <u>16</u> figures) <input checked="" type="checkbox"/> Fee Transmittal, in duplicate <u>1:526 U.S. PTO</u> <input type="checkbox"/> Other: <u> </u> <u>09/186056</u>	

11/03/98

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NOV 16 1998

B.S.T.Z. DATABASE DEPT.

To F/F Docketed

UNITED STATES UTILITY PATENT APPLICATION

FOR

A RACE FREE DATA TRANSFER ALGORITHM USING HARDWARE BASED
POLLING

Inventors:

David I. Poisner
Karthi R. Vadivelu

42390.P6344

Prepared by:

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN

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Los Angeles, California 90025-1026
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Anne H. Jacobs
(Typed or printed name of person mailing paper or fee)

Anne H. Jacobs
(Signature of person mailing paper or fee)

A RACE FREE DATA TRANSFER ALGORITHM USING HARDWARE BASED
POLLING

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BACKGROUND

1. Field of the Invention

The present invention pertains to the field of data transfers in a computer or other processing system.

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2. Description of Related Art

An improved data transfer algorithm, such as an improved direct memory access (DMA) technique, may provide advantages both in terms of improved system performance and in terms of ease of interface software (e.g., device driver) design. Improved system 15 performance may result from fewer bus transactions being used and from lengthening the total data transfer when additional data becomes available during the course of the data transfer. Simpler device drivers may be designed if the device driver software can easily obtain a precise and updated indication of the transfer status throughout the transfer.

A DMA transfer is a transfer of data (i.e., any stored information, instructions, etc.) 20 between system memory and a device with limited or no intervention from the system processor once the transfer commences. A memory region that acts as the source or target of a DMA transfer is often physically contiguous. Alternatively, some DMA controllers may allow access to scattered memory regions (i.e., they support scatter-gather). In a

DMA controller supporting scatter-gather, either multiple addresses may be programmed into the DMA controller or a data structure may be used to track the multiple regions of memory.

One advantage of using DMA-style transfers is that a large block of memory may
5 be automatically transferred without further intervention of the processor. In other words,
the controller can be initialized, and then can provide numerous bus cycles to transfer data
without further intervention. The controller, however, typically only proceeds until
reaching an endpoint programmed in during the initialization. Additionally, some
controllers provide no mechanism to notify other components or software routines of
10 progress throughout the transfer.

As a result, inefficient latencies may develop and the data transfer process may be
prematurely halted. For example, consider a transfer of buffers from memory to a DMA
device. If there is no notification until all data from memory is transferred to the DMA
device, then the space in memory used by the data is not released until the entire transfer is
15 complete. This delayed release inefficiently reserves memory despite the fact that its
contents may no longer be needed after the data transfer is complete. Moreover, additional
data may have been prepared and placed in memory during the DMA transfer. If the DMA
controller was aware of this data, it could also be transferred without interruption and re-
initialization of the DMA controller.

20 Some prior art DMA techniques, however, do allow updating a value indicating the
last buffer to be transferred during the DMA transfer. A stop bit or count may be stored at
some point in memory (e.g., a stop bit may be within the buffer structure). When
additional buffers become available for transmission, the last stop bit may be updated by

the software routine transferring the data into the additional buffers.

One problem with using a memory based stop bit is that the software routine(s) adding buffers to the list may experience a race condition with the DMA controller. Such software routines typically do not know exactly which buffer the DMA controller is 5 working on at a particular point in time. Therefore, there is a risk that a memory stop bit will be turned off by software after the DMA controller has already read the buffer and retrieved the enabled stop bit.

To overcome this race condition, one prior art approach requires the DMA controller to poll the last buffer indicator in memory. Such continuous polling may 10 disadvantageously use a large number of unnecessary bus cycles to read the pointer from memory. Additionally, such polling may still produce undesirable latencies. For example, if an additional buffer becomes ready for a transfer just after the DMA controller polls the value, the DMA controller will act on stale information until the next poll. As a result, the DMA controller may terminate a data transfer unnecessarily or at least experience a latency 15 until the next polling event since it is unaware that the additional buffer is ready.

Thus, the prior art may not provide an adequate data transfer technique. Some prior art techniques may either not allow additional transfers to be added after controller initialization, may not allow efficient independent preparation and/or reclamation of buffers, or may inject undesirable extra latencies or bus cycles.

Summary

A method and apparatus for a race free data transfer algorithm using hardware based polling is disclosed. One disclosed method transfers information between a target device and a buffer which is one of a set of buffers. The buffer is pointed to by a current buffer value stored in a controller. The current buffer value is adjusted to point to a next buffer if the current buffer value is different than a last buffer value. One of the set of buffers is serviced utilizing either the current buffer value or the last buffer value from the controller.

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-5-

Brief Description of the Figures

The present invention is illustrated by way of example and not limitation in the
5 figures of the accompanying drawings.

Figure 1 illustrates one embodiment of a system utilizing disclosed data transfer
techniques.

10 Figure 2 illustrates a flow diagram for operations of one embodiment of the
system of Figure 1.

Figure 3 illustrates one embodiment of a system utilizing a buffer descriptor table.

15 Figure 4 illustrates a flow diagram for one embodiment of the system of Figure 3.

Figure 5 illustrates a flow diagram for one embodiment of a buffer reclamation
routine.

20 Figure 6 illustrates a flow diagram for one embodiment of a buffer preparation
routine.

Detailed Description

The following description provides a race free data transfer algorithm using hardware based polling. In the following description, numerous specific details such as register names, data structure configurations, specific system arrangements, and logic partitioning and integration choices are set forth in order to provide a more thorough understanding of the present invention. It will be appreciated, however, by one skilled in the art that the invention may be practiced without such specific details. In other instances, control structures and gate level circuits have not been shown in detail in order not to obscure the invention. Those of ordinary skill in the art, with the included descriptions, will be able to implement the necessary logic circuits without undue experimentation.

The presently disclosed techniques may be used to achieve an improved DMA architecture or to facilitate other similar types of data transfer transactions. A controller utilizing disclosed techniques may use a current buffer value and a last buffer value to allow the data transfer length to be changed after the transfer has been initiated without causing a race condition to occur. In some embodiments, the presently disclosed techniques may reduce the number of overhead bus cycles required to maintain a flexible length transfer and/or may allow the use of simpler device driver software for interfacing with the controller. Additionally, a prefetch register may be used to facilitate more efficient accesses when a data structure used in the data transfer is stored in main memory.

Figure 1 illustrates one embodiment of a system using hardware based polling to maintain a race free DMA process. In Figure 1, a processor 145, a memory 150, and a DMA device 105 are coupled to a bus 140. More elaborate system architectures may be employed; however, the presently disclosed techniques are not limited to any particular system or set of device arrangements since data transfers may be implemented in a wide variety of ways. In fact, any system supporting a data transfer controller that may store values (e.g., in registers) which point to memory locations and are accessible to software routines initiating, controlling, or otherwise servicing the data transfer may be used for some embodiments.

In the embodiment shown in Figure 1, the DMA device 105 includes a DMA controller 100 and a DMA target 115. These components may be separate components or may be integrated together and/or with other components. The DMA target 115 has a data signal port 117. The DMA target 115 may send and/or receive either digital or analog signals via the port 117. Thus, the DMA device 105 may be almost any device which exchanges data with memory utilizing DMA or other similar transfers. Some examples are audio coder-decoders, modems, network interfaces, or other communication or signal exchange interfaces.

The DMA controller includes a current buffer register 110 and a last buffer register 112. Either a register as a dedicated storage location or a register as a particular entry in a general purpose storage area may be used. The current buffer register 110 and the last buffer register 112 may be implemented in a variety of manners so long as the values contained therein indicate or identify the proper buffer locations when needed. These registers allow the DMA controller 100 to track which one of a set of buffers 160

stored in the memory 150 is presently being transferred as well as the buffer at which the DMA controller 100 should stop (the last buffer).

For example, the registers may simply contain pointers to buffers in memory if a linked list type structure is used for the buffers. Alternatively, the registers may store 5 either direct or indexed pointers into an optional data structure 155 stored in memory. If the optional data structure 155 is used, the registers may point to buffer descriptors residing in a buffer descriptor table in the memory 150. In any case, the values stored in the current buffer register 110 and the last buffer register 112 adequately indicate or identify particular buffers to the DMA controller 100 and any software routines that 10 utilize this information.

The memory 150 also contains software routines. A buffer preparation routine 170 prepares buffers for a DMA transfer. If DMA data is being received by the memory 150 from the DMA target 115, then the buffer preparation routine 170 may assure that an empty buffer is ready to receive the data. If data is being transferred from the memory 150 to the DMA target 115, then the buffer preparation routine 170 may fill the buffer 15 with data to be transferred.

A buffer reclamation routine 165 recaptures one or more buffers after the DMA transfer(s) affecting the buffer(s) complete. If DMA data is being received by the memory 150 from the DMA target 115, then the reclamation routine may pass the data on 20 to the software process that requested the data and then may free the buffer. If data is being transferred from the memory 150 to the DMA target 115, then the information stored in the buffer is typically no longer needed, and the reclamation routine can mark the buffer as free. If additional DMA transfers complete before the reclamation routine

165 exits, the reclamation routine may continue to reclaim buffers.

The flow diagram of Figure 2 further illustrates operation of one embodiment of the system in Figure 1. In block 205, the current buffer register 110 and last buffer register 112 are initialized. In block 210, data is then transferred to or from the buffer indicated by the current buffer register 110.

After the transfer, an interrupt bit associated with the transferred buffer is tested in step 215. If the interrupt bit is set, then buffers are reclaimed as shown in block 225 via the buffer reclamation routine 165 (Fig. 1). Any processed buffer up to but excluding the current buffer may be reclaimed. If the buffer was a receiving buffer, the data may be transferred out and the buffer freed. If the buffer was a source buffer, the buffer may simply be marked free if the data is no longer needed.

Notably, utilizing an interrupt associated with each buffer is optional. As indicated by the dotted line 226, the reclamation routine could be an independent process which is periodically activated or which continuously frees processed buffers. In any case, the reclamation routine may be able to quickly free used buffers without waiting for the end of the entire DMA transfer because it can access the current buffer register 112 in the DMA controller and therefore determine which buffers are still needed.

In block 220, since processing of the current buffer has completed, the current buffer register 110 is incremented. Once again, the process returns to transferring data to or from the current buffer as shown in block 210. Accordingly, a series of buffers may be transferred using DMA-style data transfer techniques and the associated processed buffers may be freed for other uses.

Additionally, however, the length of the transfer may be increased by the buffer

preparation routine 170 acting as a separate process 230 while the transfer is in progress. As shown in block 235, the buffer preparation routine 170 prepares buffers for transfer. This may involve designating a free buffer to receive data or filling a buffer with data to be transferred. The buffer preparation routine then updates the last buffer register 112 as 5 shown in block 240.

Consequently, the DMA controller 100 maintains an internal and updated indication of the last buffer which is available for DMA transfer. When the DMA controller 100 decides whether to continue a DMA transfer sequence, it has current information regarding buffer availability. There may be no long latency as typically 10 occurs if the DMA controller periodically polls the memory. Thus, the efficiency of the total DMA transfer may be enhanced since a longer DMA transfer may be achieved. Furthermore, since the DMA controller 100 need not periodically poll the main memory 150 to determine the status of the buffers 160, the bus traffic from the DMA controller 100 may be reduced. This may advantageously allow increased other uses of the bus. 15 Thus, a system employing the disclosed techniques may achieve more efficient performance than prior art systems.

Figure 3 illustrates another embodiment of a system utilizing DMA controller based buffer tracking. Additionally, Figures 4-6 are flow diagrams illustrating operation of one embodiment of the system in Figure 3. Similarly to the system in Figure 1, the 20 system in Figure 3 includes a processor 345, a memory 350, a DMA controller 300, and a DMA target 315. The DMA target 315 may be an audio coder-decoder (CODEC) such as a CODEC compliant with the AC '97 Specification, Revision 1.01, September 10, 1998, published by Intel corporation of Santa Clara, California. The AC '97 specification was

publicly available at the time of filing of this application on the Internet at
<http://www.intel.com/pc-suppl/platform/ac97>.

As illustrated, the DMA controller 300 may be integrated into a bus controller 340 which also interfaces with two other buses 342 and 344 (e.g., a peripheral components 5 interconnect bus and a low pin count bus). The system of Figure 3 also includes a memory controller 320 which is coupled to the processor 345 by a bus 344, to the memory 350 by a bus 335, to the bus controller 340 by a bus 330, and to a graphics controller 325 by a bus 326.

The embodiment shown in Figure 3 has a buffer descriptor table 355 in the 10 memory 350 and utilizes index values and a buffer descriptor table base register 302 in the DMA controller 300 to reference buffer descriptors. In turn, each buffer descriptor references one of a set of buffers 360 in the memory 350. An enlarged view of one of the 15 buffer descriptors is shown below the memory 350. The buffer descriptor may include a pointer 356 which points to the memory location of the buffer. The descriptor may also include a length field 358 and a command field 354 with an interrupt on complete (IOC) field 359 and a buffer underrun policy (BUP) field 357.

The IOC field 359 may be used to indicate to the DMA controller 300 whether or 20 not it should signal an interrupt upon completion of each transfer. The BUP field 357 may indicate what the DMA controller should do if there is insufficient data to keep passing on to the DMA target 315. For example, if the DMA target 315 generates an audible audio signal, it may be desirable to continue transmitting the last value to avoid an abrupt and undesirable change in the audio. If the DMA target 315 is transmitting data, it may be preferable to interpolate, zero out, or otherwise effectuate an underrun

policy depending on the type of data being transmitted.

Referring now to the flow diagram of Figure 4, the operation of one embodiment of the system in Figure 3 is shown. In block 400, the base address of the buffer descriptor table 355 is written to the buffer descriptor table base register 302. This operation sets a reference point for the index values which will be stored in registers in the DMA controller 300. In block 405, the first set of buffers are prepared for DMA transfer prior to enabling the DMA controller 300.

After these buffers are prepared for DMA transfer, a current index value (CIV) and prefetch index value (PIV) are stored respectively in a CIV register 304 and a PIV register 306 in the DMA controller 300 as illustrated in block 410. The buffer descriptor table 355 in the memory 350 is implemented as a circular buffer with N entries. Accordingly, the DMA control logic 312 may count modulo N using the index values to implement the circular buffer structure. The index value is added to the value stored in the buffer descriptor table base register 302 to obtain the address in memory of the desired buffer descriptor.

Accordingly, the CIV register 304 points to a buffer descriptor 355a which in turn points to a buffer 360a. The PIV register 306 points to a buffer descriptor 355b (subsequent to 355a) which in turn points to a buffer 360b. Since buffer descriptors are used, the memory locations buffers 360a and 360b need not bear any particular relation to each other. The embodiment illustrated in the flow diagrams counts up from zero to N-1; however, decrementing or other appropriate counting techniques could also be used, with comparisons and offsets also being appropriately reversed where necessary.

In step 415, a last valid index (LVI) value is stored in a LVI register 308 in the

DMA controller 300. The last valid index value indicates the index (the offset into the buffer descriptor table 355 from the buffer descriptor base address stored in the table base register 302) of the last valid descriptor 355c. The last descriptor 355c points to a buffer 5 360c that is the last one prepared for a DMA transfer. Once the last valid index value is stored in the LVI register 308, the DMA controller 300 may be enabled.

In block 420, a start bit 314, which may be a bit in a control register, is set in the DMA controller 300. When the DMA controller 300 is first starting, both the buffer descriptor indicated by the current index value and the prefetch index value are fetched as indicated in block 425. During continuous operation, the DMA controller will already 10 have the current buffer descriptor and will only need to prefetch the next buffer descriptor. Notably, prefetching is not required; however, when a multiple-tier data structure such as a table using buffer descriptors is used, prefetching may increase efficiency significantly.

In step 430, the buffer indicated by the current buffer pointer (the CIV) is 15 processed. That is, the already fetched buffer descriptor is examined and the pointer to the buffer in memory is extracted as well as the length. The control logic 312 of the DMA controller 300 performs the appropriate number of read or write cycles based on the length of the buffer found in the buffer descriptor. When the transfer cycles are 20 complete, the control logic 312 may take actions in accordance with the command field 354 of the buffer descriptor.

For example, if the interrupt bit or field (IOC 359) is set or enabled, as tested in block 435, the DMA controller signals an interrupt as which may cause a reclamation routine 365 to be executed as indicated in block 440. If the IOC field 359 is not

set/enabled, the control logic 312 proceeds to compare the current index value to the last valid index. If the current buffer is the last buffer available, as tested in block 445, then the controller halts the DMA transfer as indicated in block 450.

If, however, the current index value is not equal to the last valid index, then there
5 are additional blocks to be transferred and the control logic 312 proceeds to block 455 where the current index value is set to the prefetch index value. Since the descriptor for the prefetch index value has already been prefetched, the DMA controller 300 already has the memory address of the appropriate buffer and can continue data transfer. Additionally, the prefetch index value is adjusted (e.g., in this embodiment incremented)
10 to point to the next buffer descriptor as indicated in block 460, and a prefetch of the descriptor at the new prefetch index value is scheduled as indicated in block 465.

Thereafter, the controller returns to block 430 where the (new) current buffer is processed. This process is repeated until the DMA transfer is halted (block 450) due to the exhaustion of the buffer supply (the current index value equaling the last valid index)
15 or until another event interrupts the DMA transfer.

Figure 5 illustrates one embodiment of the reclamation routine 365. The reclamation routine may be executed in response to an interrupt generated at the end of a buffer (IOC bit set), or the reclamation routine may be implemented as a separate process which repeats periodically or which runs continuously. The reclamation routine
20 maintains a head pointer (HEAD) to the last buffer that was freed. The reclamation routine or other software initially establishes the head pointer after at least one buffer is designated for transfer.

In block 500, the current index value is read from the DMA controller 300. If the
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current index value is not greater than the head pointer, as tested in block 505, then there are no buffers which have been processed and have not been reclaimed (marked as free for re-use). Therefore, the reclamation routine 365 is finished reclaiming buffers as indicated in block 510. In other embodiments that use a different counting or buffer tracking technique, different comparisons may be used throughout to determine the relationship between the head pointer and the current index value.

If the current index value is less than the head pointer, the reclamation routine 365 marks the buffer pointed to by the head pointer as free as indicated in block 515. Thus, the buffer is released relatively quickly for use by other processes or for reuse in the DMA transfer since the entire DMA transfer need not be completed before the buffer is released. As indicated in block 520, the head pointer is adjusted to point to a next potentially reclaimable buffer (e.g., in this embodiment incremented) and the process returns to reading the current index value from the DMA controller 300.

Since the reclamation process does not happen instantaneously, the current index value may have advanced, allowing additional buffers to be reclaimed. Additional interrupts which may have occurred due to the completion of the processing of other buffers may be ignored since this embodiment of the reclamation routine continues looping and re-loading the current index value until all processed buffers have been reclaimed. This aspect may be particularly advantageous where the DMA controller uses non-reentrant interrupts that may have otherwise been lost to signal the end of each buffer.

Figure 6 illustrates one embodiment of a preparation routine 370. The preparation routine 370 alters the current index value to extend the DMA transfer and include

additional buffers that became available after the DMA transfer was initiated. As indicated in block 600, the tail pointer (TAIL) is set to the current index value. If the next buffer (TAIL + 1) is not free, as tested in block 605, the routine exits in block 610. Either a lack of available buffers, data, or buffer descriptors may prevent the preparation of additional buffers. If those resources needed are available, the tail pointer is incremented in block 615.

Next, a buffer and buffer descriptor are prepared as indicated in block 620. A free buffer may be selected if the DMA transfer is scheduled to read data into memory. A buffer may be filled with data if the DMA transfer is scheduled to transfer data from memory. The memory address of the buffer may be written to the pointer field 356 of the buffer descriptor and the length and special commands may be indicated in appropriate fields as well. Notably, this or other known or otherwise available buffer preparation techniques appropriate for DMA transfers may be used.

After the buffer and buffer descriptor are prepared, the incremented tail pointer is stored in the last valid index register 308. As a result, as soon as the buffer is prepared, the DMA controller 300 may receive current information regarding the last available buffer. In some embodiments, no extraneous bus traffic is required because the software routine updates a value stored in the DMA controller 300 when data for an additional buffer is available for DMA transfer.

Thus, a race free data transfer algorithm using hardware based polling is disclosed. While certain exemplary embodiments have been described and shown in the accompanying drawings, it is to be understood that such embodiments are merely illustrative of and not restrictive on the broad invention, and that this invention not be

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limited to the specific constructions and arrangements shown and described, since various other modifications may occur to those ordinarily skilled in the art upon studying this disclosure.

What is claimed is:

1. A method comprising:

transferring information between a target device and a first buffer which is one of

5 a plurality of buffers, the first buffer being pointed to by a current buffer value stored in a controller;

adjusting the current buffer value stored in the controller to point to a next buffer if the current buffer value is different than a last buffer value stored in the controller; and

10 servicing one of the plurality of buffers utilizing one of the current buffer value and the last buffer value from the controller.

2. The method of claim 1 wherein servicing comprises:

retrieving the current buffer value from the controller;

15 comparing the current buffer value to a head pointer of a buffer list;

marking a buffer pointed to by the head pointer as being processed if the head pointer has not reached the current buffer value; and

adjusting the head pointer to point to a next potentially reclaimable buffer if the head pointer has not reached the current buffer value.

20

3. The method of claim 1 wherein servicing comprises:

preparing a buffer pointed to by an incremented tail pointer; and

storing the incremented tail pointer as the last buffer value in the controller.

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4. The method of claim 1 wherein the current buffer value is a first index into a buffer descriptor table and wherein the current buffer value points to the first buffer by pointing to a buffer descriptor offset by the first index from a buffer descriptor table base location.

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5. The method of claim 4 further comprising:

prefetching a next buffer descriptor from the buffer descriptor table.

10 6. The method of claim 1 further comprising:

testing an interrupt field to determine whether the interrupt field is set to a first value to interrupt upon completion of processing the first buffer; and generating an interrupt if the interrupt field is set to the first value.

15 7. The method of claim 1 further comprising:

executing a buffer underrun routine according to a command field associated with the first buffer if there are no further buffers available for transfer.

8. A bus agent comprising:

20 a current buffer register for storing a first value indicating a first memory location for a current buffer;

a last buffer register for storing a second value indicating a second memory location for a last buffer ready for processing; and

control logic coupled to transfer data to or from the current buffer and to update the current buffer register to point to a next buffer unless the first value from the current buffer register is equivalent to the second value from the last buffer register.

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9. The bus agent of claim 8 wherein the current buffer register contains a first index value and wherein the first index value in the current buffer register indicates the first memory location by pointing to a first buffer descriptor in a buffer descriptor table, the first buffer descriptor being the first index value locations from a buffer descriptor

10 table base.

10. The bus agent of claim 9 wherein the last buffer register contains a second index value and wherein the second index value in the last buffer register indicates the second memory location by pointing to a second buffer descriptor in the buffer descriptor table, the second buffer descriptor being the second index value locations from the buffer descriptor table base.

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11. The bus agent of claim 10 further comprising

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a prefetch buffer register, wherein the control logic is coupled to set the current buffer register equal to a value in the prefetch buffer register, to increment the value in the prefetch buffer register, and to schedule a prefetch of a buffer descriptor pointed to by the prefetch buffer register.

12. The bus agent of claim 8 wherein the current buffer register contains a first pointer to a linked list of buffers in memory and wherein the last buffer register contains a second pointer to a last buffer in the linked list of buffers in memory.

5 13. A system comprising:

a bus controller comprising:

a current buffer register for storing a first value indicating a memory location
of a current buffer;

10 a last buffer register for storing a second value indicating a memory location
of a last buffer, the last buffer being the last buffer which is prepared for
processing; and

control logic coupled to transfer data to or from the current buffer and to update
the current buffer register to point to a next buffer unless the first value is
equivalent to the second value;

15 a processor; and

a memory coupled to the processor, the memory containing:

a plurality of buffers including the current buffer and the last buffer;

at least one software routine which, if executed, causes the system to service
at least one of the plurality of buffers utilizing information stored in one of
20 the current buffer register and the last buffer register.

14. The system of claim 13 wherein the memory further contains:

a buffer descriptor table having a plurality of buffer descriptors pointing to the

plurality of buffers, and

wherein the current buffer register contains a first index value, the first index
value in the current buffer register indicating the current buffer by pointing
to a first buffer descriptor in the buffer descriptor table, the first buffer
descriptor being the first index value locations from a buffer descriptor
table base.

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15. The system of claim 14 wherein the last buffer register contains a second index value,

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the second index value in the last buffer register indicating the last buffer by pointing
to a second buffer descriptor in the buffer descriptor table, the second buffer
descriptor being the second index value locations from the buffer descriptor table
base.

base.

16. The system of claim 13 wherein the current buffer register contains a first pointer to a

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linked list of buffers in memory and wherein the last buffer register contains a second
pointer to a last buffer in the linked list of buffers in memory.

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17. The system of claim 13 wherein the bus controller further comprises a prefetch buffer
register and wherein the control logic is further coupled to set the current buffer
register equal to a value stored in the prefetch buffer register, to increment the
prefetch buffer register, and to schedule a prefetch of a prefetch buffer descriptor
pointed to by the prefetch buffer register.

18. The system of claim 13 wherein the at least one software routine comprises:

a preparation routine which, if executed, causes the system to perform:
preparing a buffer pointed to by an incremented tail pointer; and
storing the incremented tail pointer in last buffer register.

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19. The system of claim 13 wherein the at least one software routine comprises:

a reclamation routine which, if executed, causes the system to perform:
retrieving a current buffer value from the current buffer register;
comparing the current buffer value to a head pointer of a buffer list;
marking a buffer pointed to by the head pointer as being processed if the head
pointer has not reached the current buffer value; and
adjusting the head pointer to point to a next potentially reclaimable buffer if
the head pointer has not reached the current buffer value.

15 20. A system comprising:

a processor;

a bus agent comprising:

a current index register;

a prefetch index register; and

20 a last index register;

a buffer descriptor base address register;

control logic coupled to transfer data to or from a buffer pointed to by the

current index register, to stop retrieving data if the current index register

and the last index register contain equivalent values, to set the current index register equal to the prefetch index register, to increment the prefetch index register, and to schedule a prefetch of a prefetch buffer descriptor pointed to by values stored in the prefetch index register and the buffer descriptor base address register.

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a memory coupled to the processor and the bus agent containing:

a table storing a plurality of buffer descriptors

a preparation routine which, if executed, causes the system to perform:

checking an incremented tail index to determine whether the

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incremented tail index points to a free buffer;

if the incremented tail index points to the free buffer, then

preparing the free buffer by storing data to be retrieved by the

bus master into the free buffer;

storing the incremented tail index in the last index register;

15

a reclamation routine which, if executed, causes the system to perform:

retrieving a current index value from the current index register;

comparing the current index value to a head pointer;

if the head pointer is less than the current index value, then

marking a buffer pointed to by the head pointer as free;

20

incrementing the head pointer;

returning to comparing the current index value to the head

pointer.

21. An article comprising a machine readable medium having stored thereon a plurality of instructions which, if executed by the machine, cause the machine to perform:

transferring information between a direct memory access (DMA) controller and a first buffer which is one of a plurality of buffers, the first buffer being pointed to by a current buffer register in the DMA controller;

5 adjusting the current buffer register to point to a next buffer if the current buffer register contains a different value than a last buffer register; and servicing one of the plurality of buffers utilizing information contained in one of the current buffer register and the last buffer register.

10

22. The article of claim 21 wherein the servicing performed by the machine further comprises:

retrieving a first value from the current buffer register;

comparing the first value to a head pointer of a buffer list;

15 marking the buffer pointed to by the head pointer as being processed if the head pointer has not reached the first value; and

adjusting the head pointer to point to a next potentially reclaimable buffer if the head pointer has not reached the first value.

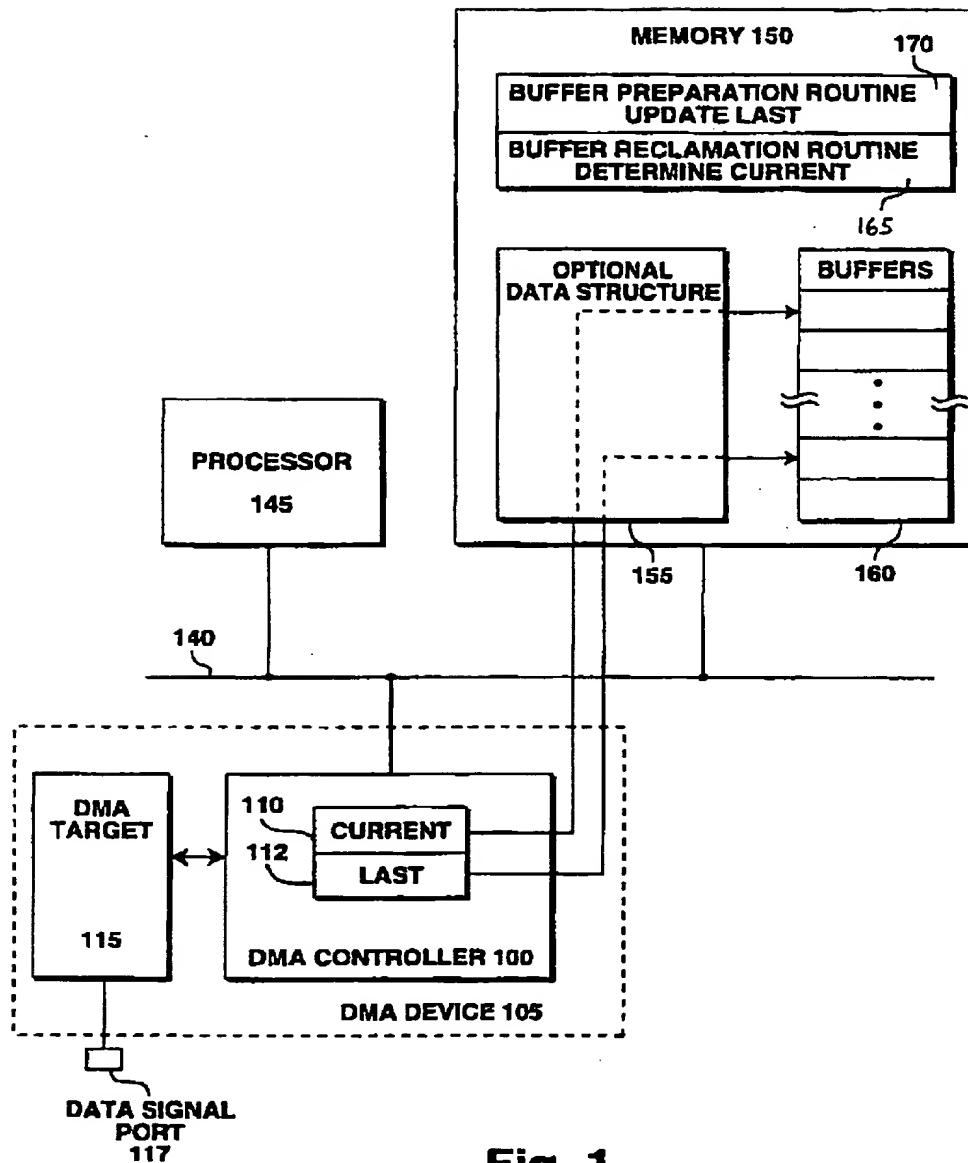
20 23. The article of claim 21 wherein the servicing performed by the machine further comprises:

preparing a buffer pointed to by an incremented tail pointer; and

storing the incremented tail pointer in last buffer register.

Abstract

5 A method and apparatus for a race free data transfer algorithm using hardware
based polling. One disclosed method transfers information between a target device and a
buffer which is one of a set of buffers. The buffer is pointed to by a current buffer value
stored in a controller. The current buffer value is adjusted to point to a next buffer if the
current buffer value is different than a last buffer value. One of the set of buffers is
10 serviced utilizing either the current buffer value or the last buffer value from the controller.



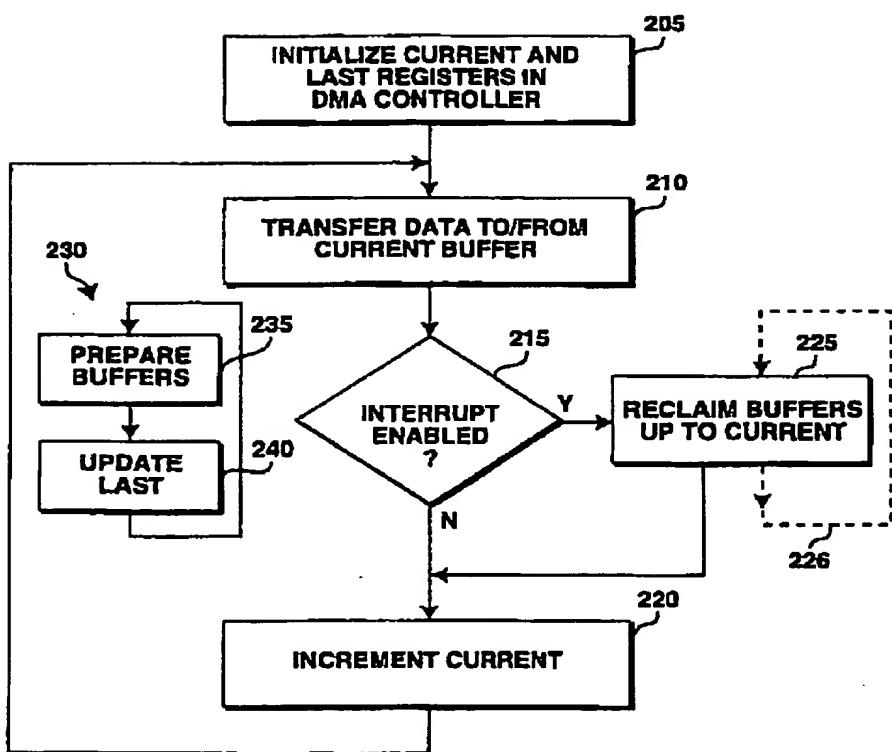


Fig. 2

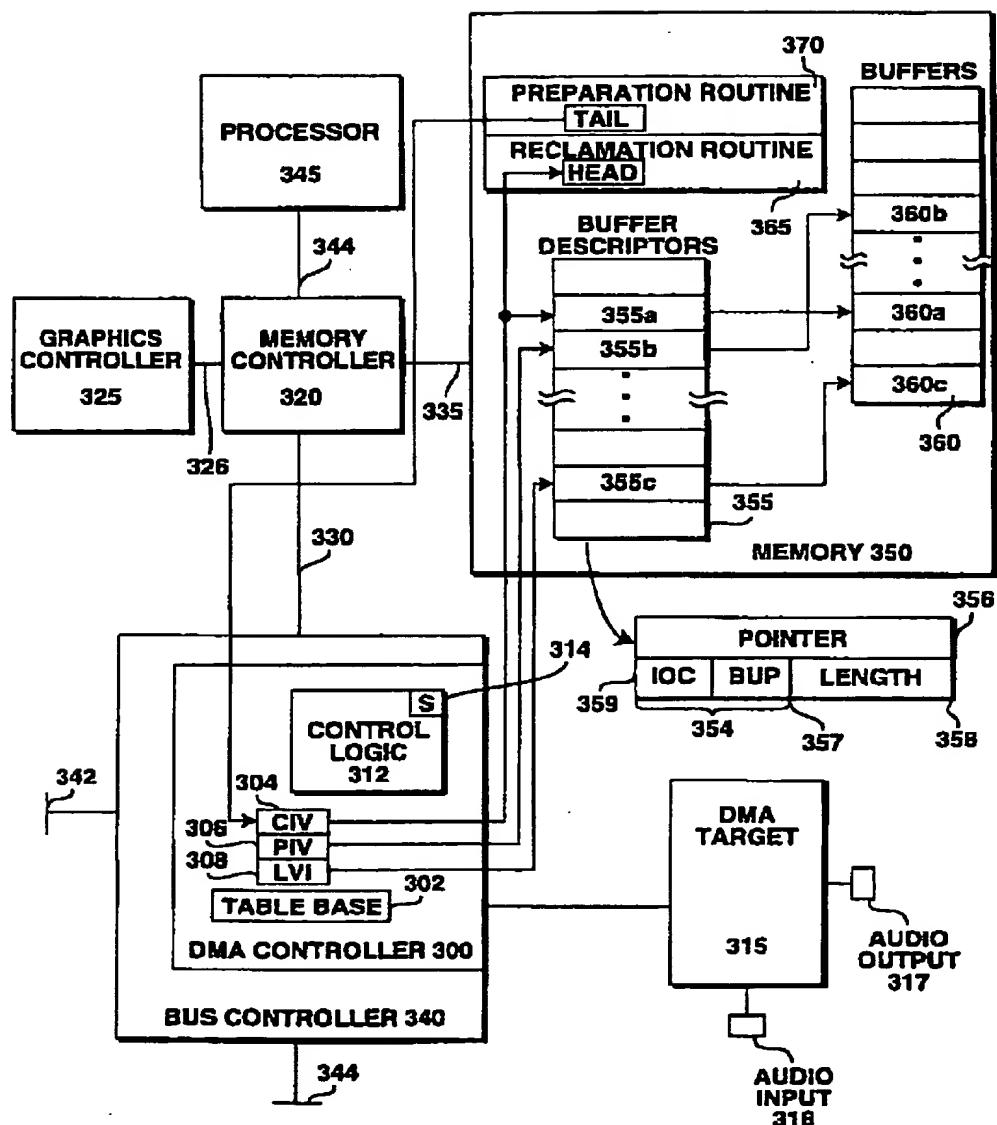


Fig. 3

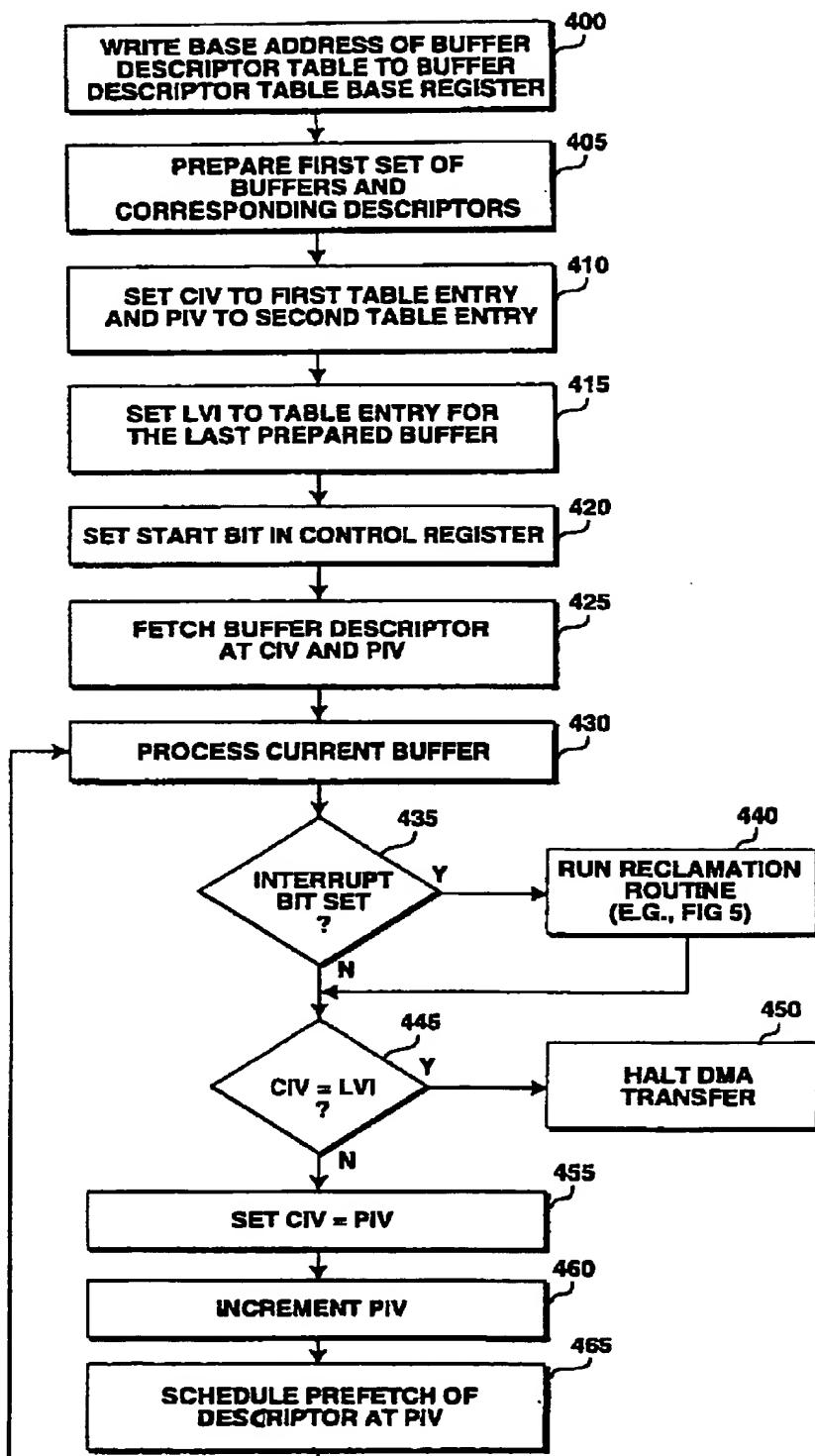


Fig. 4

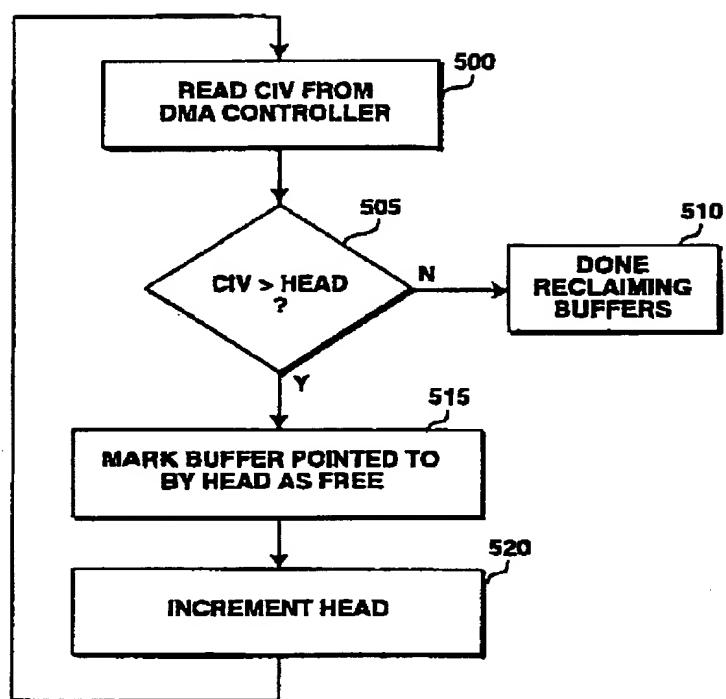


Fig. 5

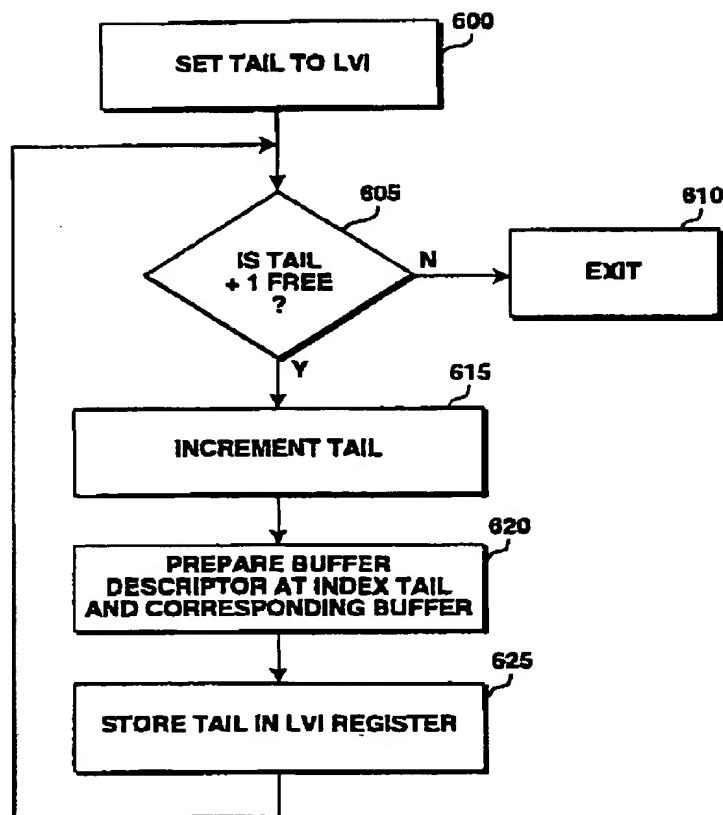


Fig. 6